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North Dakota State University

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SOLAR TRACKER FINAL REPORT

It's a solar tracker!

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Background

Design and develop a controller that can be retrofitted to a dual-axis solar photovoltaic tracker system. The device inputs should be the time of day and a person's latitude and longitude to determine and control optimal panel positioning. The system should be relatively inexpensive and possibly be adaptable to fit other tracker systems.

Currently the user has light sensors that he has had to replace and he is looking for a suitable replacement. He currently has two solar panels that he would like to have our system implemented on one of them and compare the efficiencies of the photo-sensor versus a GPS tracking system. He had expressed the need for want an automatic and also a manual control of the location of the panels one of the main components required in our project as requested by the client is to be able to find a user's longitude and latitude and have the panels move to the appropriate location. Bulleted below are some more specific details.

Requirements

- Currently the system will have to be compatible with both single and dual axis panels
- Current Power that has to be compatible with is a 24V system
- The Panels Have the capability to go 85 degrees to flat and limit on the horizontal axis rotation
- Automatic and manual modes desired
- The ability to switch between single and dual axis mode also desired
- High grade equipment is desired to withstand extreme conditions
- A Wind sensor must be incorporated to the system to allow the panels to go into a horizontal mode for high winds

Previous Works:

Wattsun

Array Technologies manufactures Azimuth Trackers for medium-to-large residential PV systems. Our Azimuth Tracker gear drive rotates the PV array on the pole mount so the bottom edge of the array always remains parallel to the ground. The result: a low profile and exceptional stability in the wind. A Dual-Axis Tracker enables automatic tracking of the sun's elevation as well. Dual-axis trackers completely capture all the power the sun delivers.

- AZ-225 Azimuth Gear Drive

- Dual-Axis Included
- Mounts up to 3500 Watts
- Up to 225 Sq. Ft. of PV array

Wattsun active trackers are environmentally-friendly and are guided by a patented, optical, sun-sensing device that dramatically outperforms passive tracking systems. Solid state electronic design and positive drive mechanisms insure consistent operation in extreme temperatures and windy conditions.

SunTracer

SunTracer has a dual axis solar tracker. It can have an elevation angle from 15-90 degree. It makes use if the linear motor SM4S900M3 with stroke of 900nm. The tracking accuracy is less than 0.5 degrees and makes use of the protocol TdAPS (Time derived Astronmical Positioning System). It is possible to connect to a PC through USB. It can operate in temperature from -25C to 75C and withstand wind speeds from 130km/h.

SunTura

The main tracker mount holds two linear actuators and this is what moves the solar panels throughout the day. The main tracker mount is constructed from 6061 aluminum and stainless steel fasteners. The linear actuators are each rated to move 225 pounds of weight and each linear actuator can hold up to 450 pounds of static weight. One water-tight, epoxy sealed electronic sun tracker board ("the brain") is used for the controls. The brain is a solid state electronic control board which utilizes their proprietary software to track the sun with sub-degree accuracy and precision. The brain also has three manual switches mounted on it. Two of the switches allow you to manually move the tracker north/south/east/west and the third switch turns the tracker on/off. Manual maneuvering of a tracker is very convenient when you want to access the solar panels for cleaning or to position the solar panels parallel to the ground during extremely high winds. Four photo sensor mounts onto your tracking system . The four photo-sensors collect light from the sun and the brain uses this information to move the two linear actuators to track the sun.

Solaria

Structurally certified to withstand wind loads of 90mph (145 km/h) in all directions with an autonomous controller. Only one controller required for every 750kW for greater reliability. This is only a single axis Azimuth tracker which makes use of a double worm gear unit with a 3 phase AC motor. The controller is PLC-based that monitor position.

Design Options:

The following list includes part that we will use and the advantages and disadvantages. There is also a reason for why we choose the part.

Method of powering:

The solar tracking in place has a 24V power line in place that will would tap off of to power our controller.

GPS:

Linx Technologies: Digi key P/N RXM-GPS-SR

Advantages:

- Low Power Consumption
- -40C to 85C
- No programming necessary
- Outputs data: Longitude, Latitude, Time, and altitude
- Battery backed SRAM
- Uses up to 20 satellites
- No external RF components needed
- Uses TX and RX lines

Disadvantages:

- Surface mount only
- Needs power supply noise to be less than 20mV to be accurate
- Have static sensitive parts in it
- Cost($50)
- Needs to be away from noisy devices on PCB

We are choosing this GPS module because it has the necessary data outputs that we need and the temperature that it can handle. This was also one of the more simpler GPS module with least amount of pins that will need soldering for testing purposes. It did cost more but we can handle that if it make it a little simpler.

Regulator:

LM2576/LM2576HV Series - SIMPLE SWITCHER® 3A Step-Down Voltage Regulator
24V to 5V LM2576T-5.0-ND
Advantages:

- The regulator guarantees a 3A output current
- Wide input range to compensate for power fluctuations
- High efficiency
- Thermal shutdown protection
- Fixed frequency internal oscillator
- High Temp Thresholds

Disadvantages:

- Output Voltage Ranges from 4.8-5.2V

We are using this part to bring our 24V power supply down to 5V useable power supply for our components.

Digital Compass:

3-Axis Digital Compass IC - HMC5983
Digi key 342-1092-1-ND
Advantages:

- -30C to 85C
- Make use of I^2C lines on PIC
- Up to 3.4MHz speed on I^2C
- 1 to 2 degree accuracy
- 12-Bit ADC Coupled with Low Noise AMR Sensors
- Software and Algorithm Support Available

Disadvantages:

- Will have unused temperature sensor ability
- May require more software time to get to work
- Surface mount

This will be used for orientation purposes. With this, we will know which way is easy, west and the elevation of the device.

Microprocessor:

Microchip PIC18F4620
DigiKey P/N PIC18F4620-I/P-ND
Advantages:

- Used before in class Familiar with microcontroller
- Comes with a compiler
- Has enough ports to handle our devices
- Has a boot loader
- Cost effective
- Optimized C language Compiling
- -40C to 125C

Disadvantages

- Does not have built in Trig functions
- In comparison to other chips it is fairly large in size

This component is going to be the brain of our project it will be in charge of doing calculations and running the entire project it will have to send and receive from both the GPS unit and the digital compass and tell the motors to rotate accordingly

Timelines:

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Requirements Capture meeting					x											
Requirements Capture Document						x										
Options Considered							x									
Order Parts								x								
Make Schematic in Multisim									x							
Program PIC										x						
Breadboard PIC (maybe w/o sensors)										x	x	x				
Interface w/ sensors and motor										x	x	x				
>>> Sensors											x	x				
>>> PIC											x	x				
>>> Motor											x	x				
Progress Report:												x				
>>> Progress on PIC												x				
>>> Progress on motor, and enclosure												x				
Revise Schematic in Multisim												x				
Start PCB layout in Ultiboard													x			
Finalize PCB layout (Ultiboard)														x		
Prepare for presentation															x	
Presentations, end of semester																x

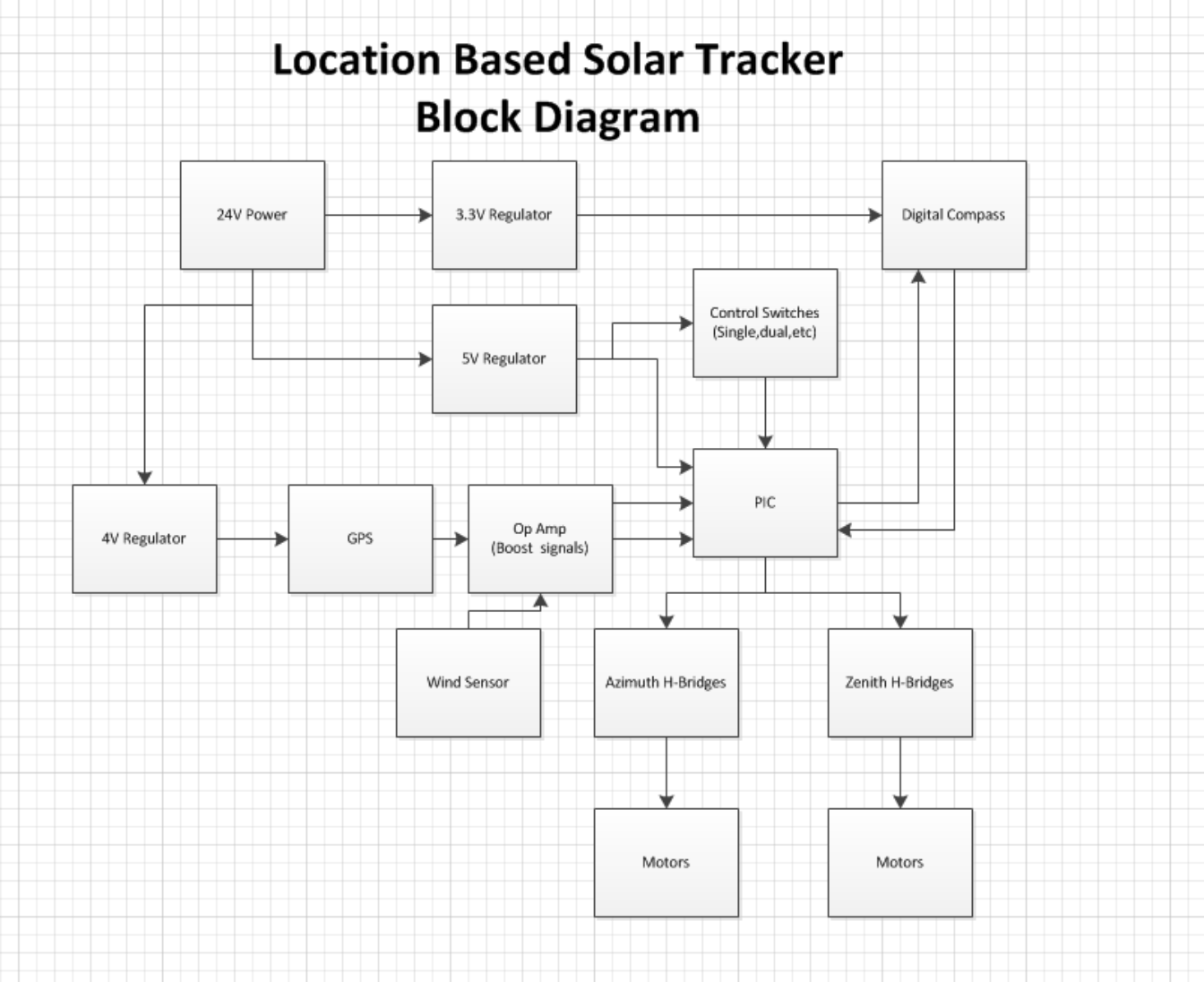
Since there is only two people working on this project, We will be doing everything together as a group and spilt the task up if the need arises.

Week	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Requirements Capture Update	x													
Order Motor	x													
Order Parts	x	x												
Make Schematic in Multisim						x	x							
Program PIC		x	x	x	x	x								
Breadboard PIC (maybe w/o sensors)		x	x	x	x	x								
Interface w/ sensors and motor			x	x	x	x								
Progress Report:							x							
Revise Schematic in Multisim								x	x					
Start PCB layout in Ultiboard									x	x				
Finalize PCB layout (Ultiboard)										x	x			
Prepare for presentation											x	x	x	
Presentations, end of semester														x

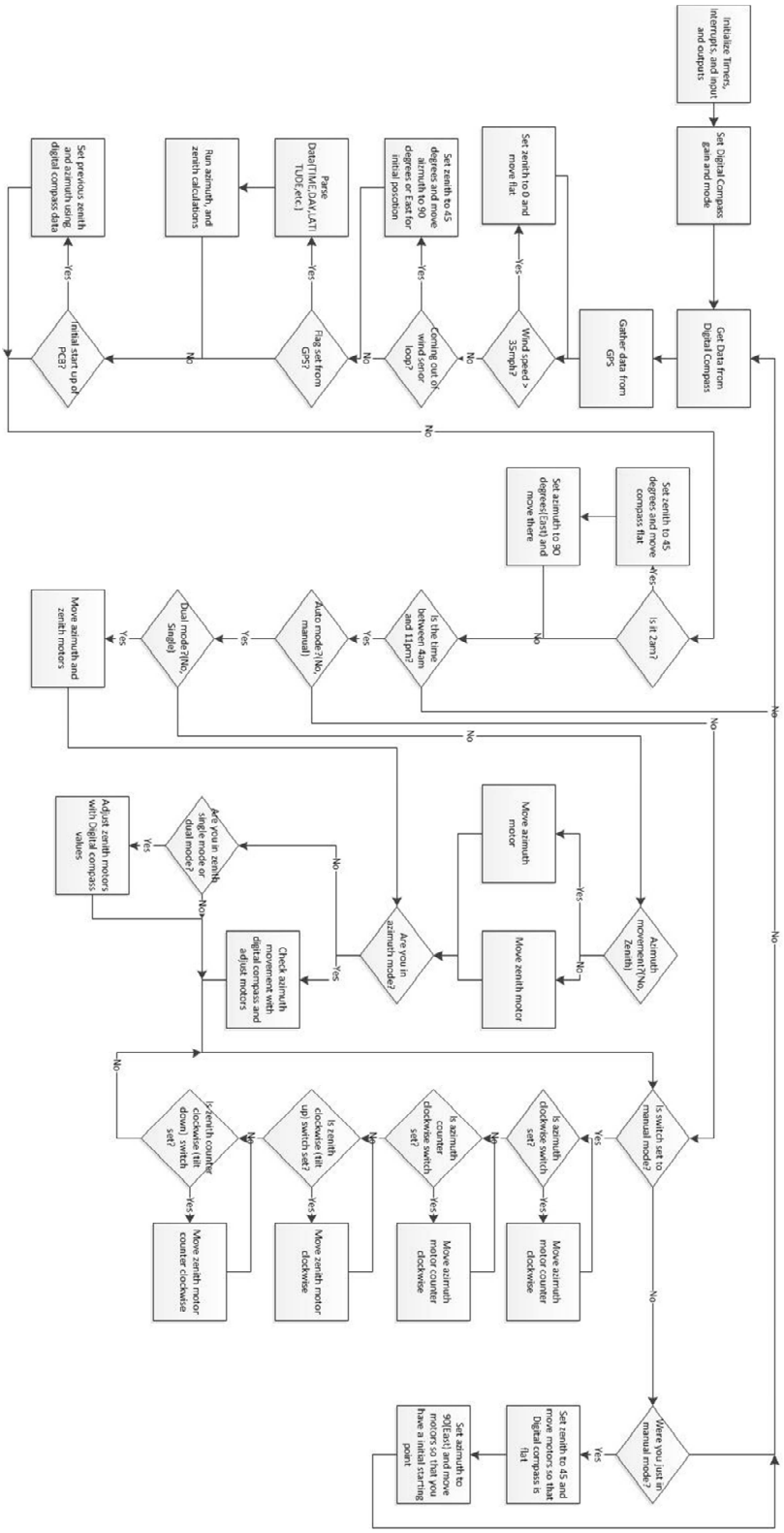
Budget

Item #	Item Description	Price per Unit	Quanity	Total Cost
1	PIC Microcontroller	$30	2	$60
2	Precision Regulator	$3.00	4	$12
3	Voltage Regulators	$8	4	$32
4	GPS	$50	3	$150
5	Components	$60.00	1	$60
6	PCB	$66	1	$66
7	Digital Compass	$10.00	4	$40
8	Motors	$180	1	$180
9	H-bridges	$6.00	6	$36
			Total	$636

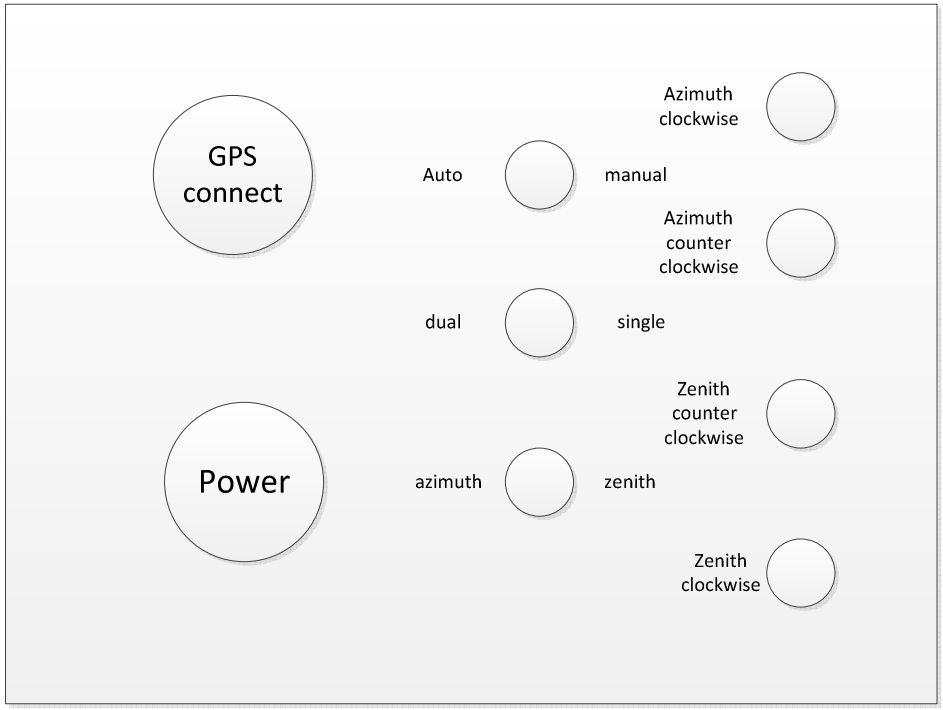
Block Diagram

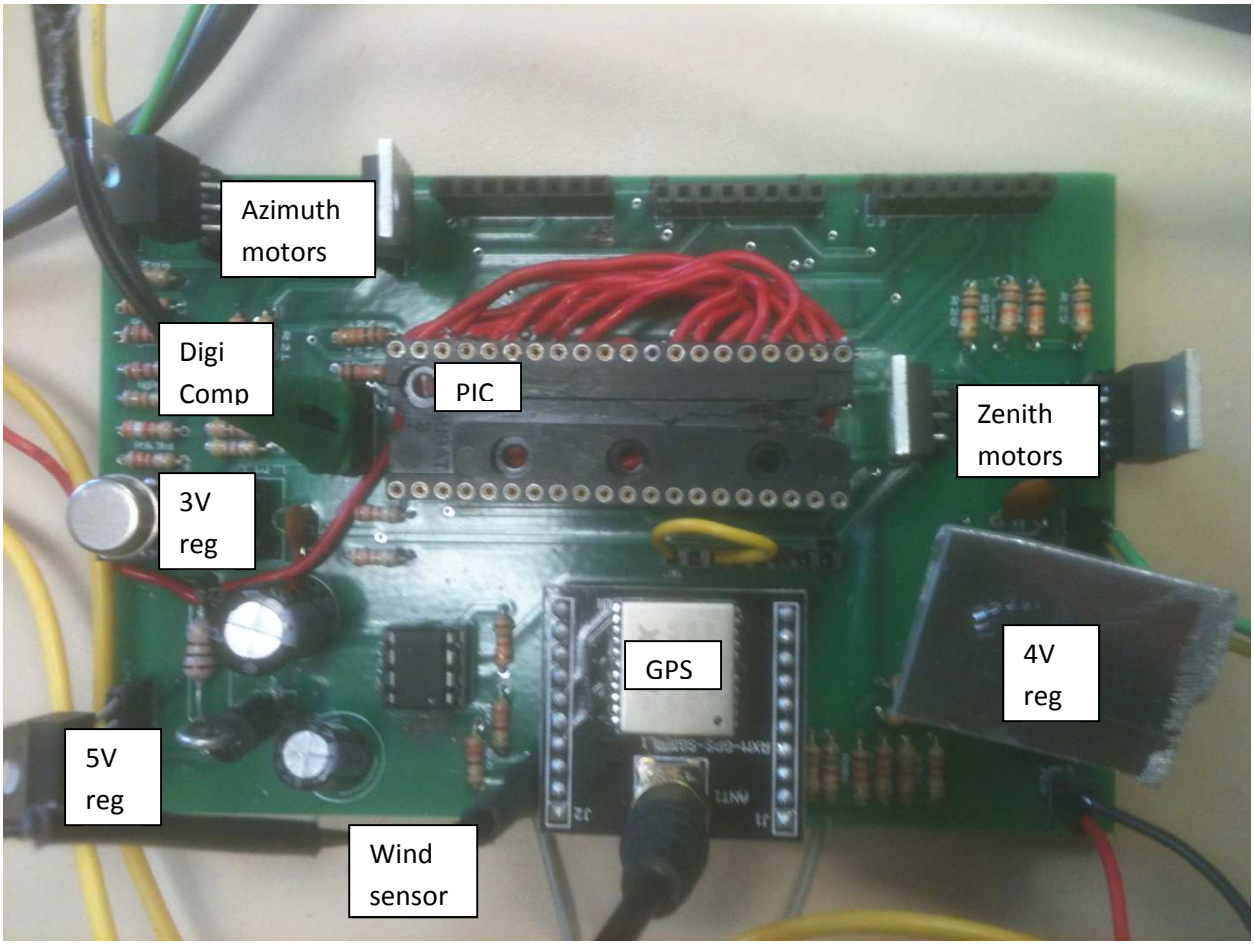


Flowchart


Initialize Timers, interrupts, and inputs
Set Digital Compass gain and mode
Get Data from Digital Compass
Gather data from GPS
Wind speed > 35mph?
Set zenith to 0 and move flat
Coming out of wind sensor loop?
Set zenith to 45 degrees and move azimuth to 90 degrees or East for initial position
Flag set from GPS?
Parse Data(TIME,DAY,LAT/LOT,etc.)
Run azimuth, and zenith calculations
Initial start up of PC?
Set previous zenith and azimuth using digital compass data
No
Yes
Is it 2am?
Set zenith to 45 degrees and move compass flat
Set azimuth to 90 degrees(East) and move there
Is the time between 4am and 11pm?
Auto mode?(No, manual)
Dual mode?(No, Single)
Move azimuth and zenith motors
Azimuth movement?(No, Zenith)
Move azimuth motor
Move zenith motor
Are you in azimuth mode?
Check azimuth movement with digital compass and adjust motors
Are you in zenith single mode or dual mode?
Adjust zenith motors with Digital compass values
Is switch set to manual mode?
Is azimuth clockwise switch set?
Move azimuth motor counter clockwise
Is azimuth counter clockwise switch set?
Move azimuth motor clockwise
Is zenith clockwise (tilt up) switch set?
Move zenith motor clockwise
Is zenith counter clockwise (tilt down) switch set?
Move zenith motor counter clockwise
Were you just in manual mode?
Set zenith to 45 and move motors so that Digital compass is flat
Set azimuth to 90[East] and move motors so that you have a initial starting point

Pictures of Device



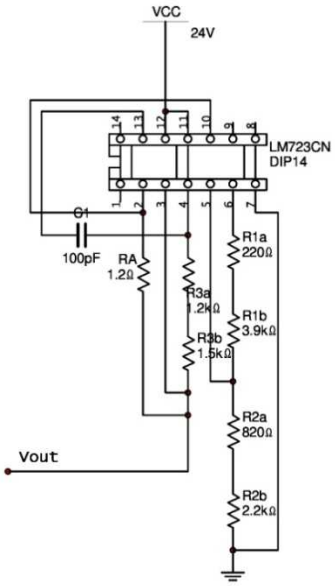

Azimuth motors
Digi Comp
PIC
Zenith motors
3V reg
GPS
4V reg
5V reg
Wind sensor

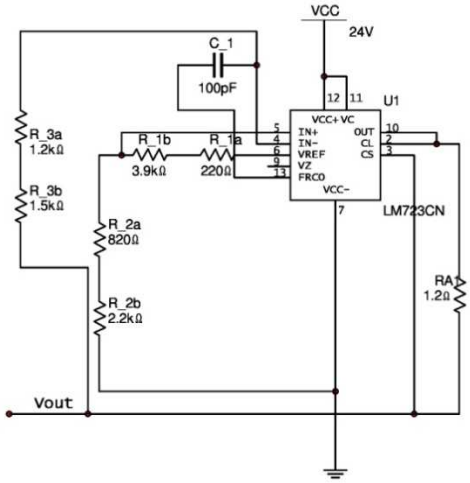
Schematics

In this section will include all of the schematics from the individual parts to the large schematics including all components that eventually went to fabrication. The software program to produce the schematics is National Instruments Multisim and Ultiboard version 8 of the software. Also in this section there is our second revisions of the main PCB layout, they will be marked accordingly.

3 Volt Regulator

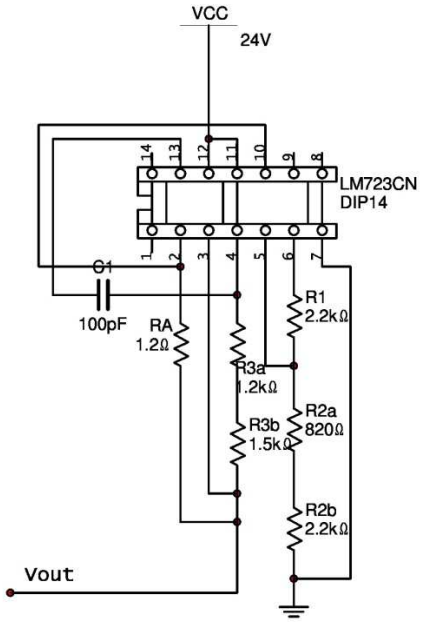
The 3 Volt Regulator is primarily used for our digital compass to power the device it takes in 24V and brings it down to 3V.

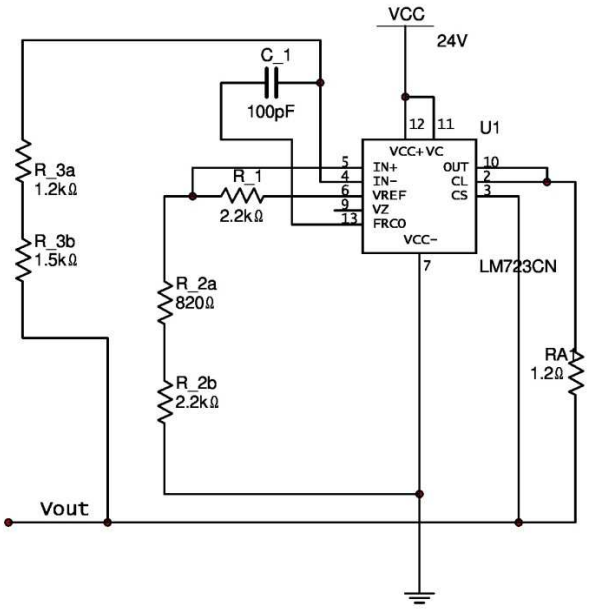




4 Volt Regulator

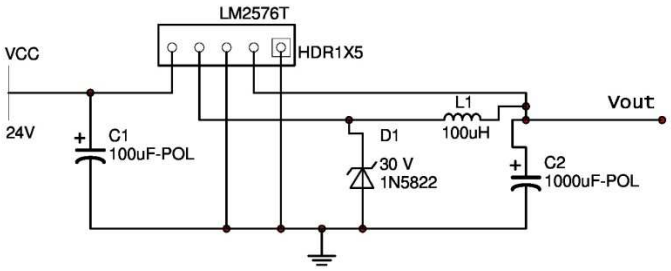
The 4V Regulator is primarily used for the GPS Unit and takes in 24V and knocks it down to 4V.





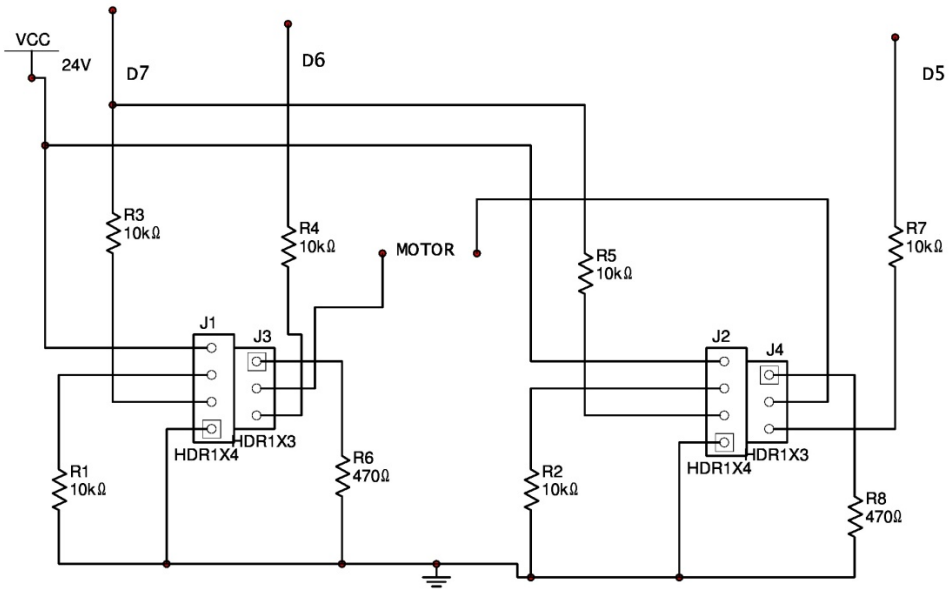
5 Volt Regulator

The 5V Regulator is the most common used power supply in our circuit it is primarily used to power the PIC Microprocessor and in our switches to pull values to the high value to enable the PIC to read a value of 1. Also this regulator will take in a 24V and knock it down to 5V.



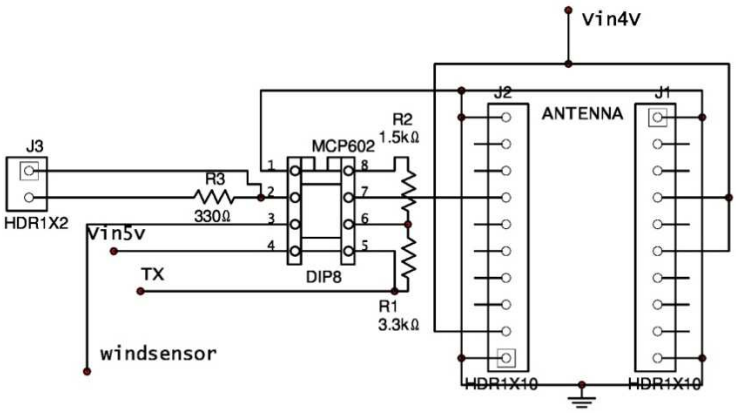
H-Bridge

The H-Bridge circuit is our primary way to move the motors we use a half bridge configuration and put two of them together to make a full bridge configuration. We also use two of our full bridge configurations, one for azimuth and one for zenith movements.



GPS Breakout

The GPS Unit is a chip we had bought that is one of the main pieces of hardware that we use in our project it gathers a lot of the data that is used in our project. We had to design custom header slots for our chip to fit in.



Digital Compass

The Digital Compass is our primary form of checking our current position relative to north.